

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
10 September 2004 (10.09.2004)

PCT

(10) International Publication Number
WO 2004/076798 A3

(51) International Patent Classification⁷: **E21B 23/08**

(74) Agent: **MATTINGLY, Todd; Haynes and Boone, LLP**,
901 Main Street, Suite 3100, Dallas, TX 75202 (US).

(21) International Application Number:
PCT/US2004/006246

(22) International Filing Date: 26 February 2004 (26.02.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/450,504 26 February 2003 (26.02.2003) US

(71) Applicant (for all designated States except US): **ENVENTURE GLOBAL TECHNOLOGY [US/US]**; 16200 A.
Park Row, Houston, TX 77084 (US).

(72) Inventor; and

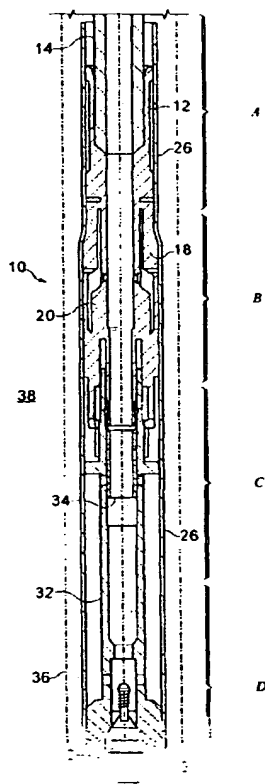
(75) Inventor/Applicant (for US only): **BRISCO, David, Paul**
[US/US]; 405 Westridge Drive, Duncan, OK 73533 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NJ, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK,

[Continued on next page]

(54) Title: **APPARATUS FOR RADIALY EXPANDING AND PLASTICALLY DEFORMING A TUBULAR MEMBER**



(57) Abstract: An apparatus (10) for radially expanding and plastically deforming a tubular member (26) with a support member (14), tubular support (12), expansion cone (18), support (20), sliding valve (34), tubular (32), one way poppet valve (30), and shoe (28) in a wellbore (36) at a formation (38) of interest.

WO 2004/076798 A3

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— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

Declaration under Rule 4.17:

— of inventorship (Rule 4.17(iv)) for US only

(88) Date of publication of the international search report:

24 March 2005

Published:

— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/06246

| A. CLASSIFICATION OF SUBJECT MATTER IPC(7) : E21B 23/08 US CL : 166/285, 287, 207, 177.4 According to International Patent Classification (IPC) or to both national classification and IPC | | |
|--|--|--|
| B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) U.S. : 166/285, 287, 207, 177.4 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) | | |
| C. DOCUMENTS CONSIDERED TO BE RELEVANT | | |
| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
| X | US 6,085,838 A (Vercaemer et al.) 11 July 2000 (11.07.2000), whole document | 4-8 |
| X | US 5,718,288 A (Bertet et al.) 17 February 1998 (17.02.1998), whole document | 10, 11, 13, 15-17, 21, 23, 25-27, 29, 30, 32-34 |
| <input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex. | | |
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| Date of the actual completion of the international search 21 October 2004 (21.10.2004) | | Date of mailing of the international search report 26 JAN 2005 |
| Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703) 305-3230 | | Authorized officer David J. Bagnell <i>David J. Bagnell</i> Telephone No. 308-1113 |

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/06246

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 24
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
Claim 24 is missing
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

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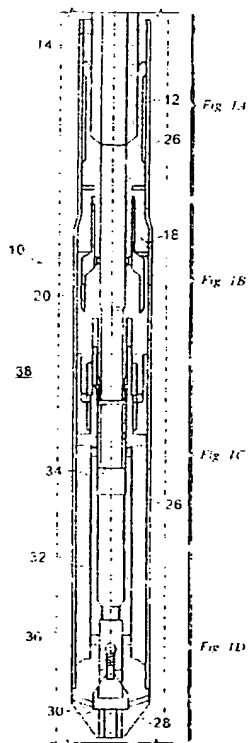
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WO 2004/076798 A3



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(88) Date of publication of the international search report:

24 March 2005

Declaration under Rule 4.17:

— of inventorship (Rule 4.17(iv)) for US only

Date of publication of the amended claims:

16 June 2005

Published:

— with international search report

— with amended claims

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AMENDED CLAIMS

[received by the International Bureau on 21 March 2005 (21.03.05)
original claims 4 and 10 amended and claims 35 to 55 added (13 pages).]

What is claimed is:

1. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:
 - a tubular support member defining an internal passage and one or more radial passages and comprising internal splines;
 - a tubular expansion cone coupled to the tubular support member comprising an external expansion surface;
 - one or more rupture discs coupled to and positioned within corresponding radial passages of the tubular support member;
 - a tubular stinger defining an internal passage coupled to and positioned within the tubular support member;
 - an expandable tubular member coupled to the expansion surface of the tubular expansion cone comprising a first portion and a second portion, wherein the inside diameter of the first portion is less than the inside diameter of the second portion;
 - a shoe defining one or more internal passages coupled to the second portion of the expandable tubular member;
 - a tubular member coupled to the shoe defining an internal passage comprising a plug seat, one or more upper radial flow ports positioned above the plug seat, and one or more lower radial flow ports positioned below the plug seat, and comprising an external flange for sealingly engaging the interior surface of the expandable tubular member and external splines for engaging the internal splines of the tubular support member, wherein an end of the tubular member receives an end of the tubular stinger and is also received within and sealingly engages an end of the tubular support member; and
 - a tubular sliding sleeve valve received within and sealingly engaging the internal passage of the tubular member defining an internal passage and one or more radial passages and comprising a collet for releasably engaging an end of the tubular stinger.
2. The apparatus of claim 1, wherein the radial passages of the tubular support member are positioned above the tubular stinger.
3. The apparatus of claim 1, wherein at least a portion of the tubular member comprises a composite material.

4. A system for radially expanding and plastically deforming a tubular member within a preexisting structure, comprising:
 - pressure sensing means for radially expanding and plastically deforming the tubular member within the preexisting structure; and
 - means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure.
5. The system of claim 4, wherein the means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure comprises:
 - means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure before radially expanding and plastically deforming the tubular member within the preexisting structure.
6. The system of claim 4, wherein the means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure comprises:
 - means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure before or after radially expanding and plastically deforming the tubular member within the preexisting structure.
7. A method of radially expanding and plastically deforming a tubular member within a preexisting structure, comprising:
 - radially expanding and plastically deforming the tubular member within the preexisting structure; and
 - injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure.
8. The method of claim 7, wherein injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure comprises:
 - injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure before radially expanding and plastically deforming the tubular member within the preexisting structure.
9. The method of claim 7, wherein injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure comprises:
 - injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure after radially expanding and plastically deforming the tubular member within the preexisting structure.

10. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:
- a support member;
 - an expansion device coupled to the support member comprising rigid external expansion surface;
 - one or more pressure sensors coupled to the support member;
 - an expandable tubular member coupled to the rigid expansion surface of the expansion device comprising a first portion and a second portion, wherein the inside diameter of the first portion is less than the inside diameter of the second portion; and
 - a movable valve coupled to the support member for controlling the flow of fluidic materials through the interior of the expandable tubular member.
11. The apparatus of claim 10, wherein the pressure sensors comprise frangible elements.
12. The apparatus of claim 10, wherein the pressure sensors comprise valve elements for controlling the flow of fluidic materials within the interior of the expandable tubular member.
13. The apparatus of claim 12, wherein the support member defines one or more radial passages; and wherein the valve elements are positioned within corresponding radial passages.
14. The apparatus of claim 10, further comprising:
- a tubular member movably coupled to the support member that defines an internal passage having a plug seat.
15. The apparatus of claim 14, wherein the movable valve is received within the internal passage of the tubular member.
16. The apparatus of claim 15, wherein the tubular member defines one or more radial passages; and wherein the movable valve defines one or more radial passages.
17. The apparatus of claim 14, wherein the tubular member sealingly engages an interior surface of the expandable tubular member.

18. The apparatus of claim 14, wherein the tubular member is coupled to the second portion of the expandable tubular member.
19. The apparatus of claim 10, wherein the movable valve element is releasably coupled to the support member.
20. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:
- a support member defining one or more radial passages;
 - an expansion device coupled to the support member comprising an external expansion surface;
 - one or more frangible valve elements coupled to and positioned within corresponding radial passages of the support member;
 - an expandable tubular member coupled to the expansion surface of the expansion device comprising a first portion and a second portion, wherein the inside diameter of the first portion is less than the inside diameter of the second portion;
 - a tubular member defining an internal passage having a plug seat and one or more radial passages movably coupled to the support member and coupled to the second portion of the expandable tubular member and sealing engaging an interior surface of another portion of the second portion of the expandable tubular member; and
 - a movable valve defining one or more radial passages releasably coupled to the support member and positioned within the internal passage of the tubular member.
21. A method of radially expanding and plastically deforming a tubular member within a preexisting structure, comprising:
- injecting fluidic material into the tubular member;
 - sensing the operating pressure of the injected fluidic material; and
 - if the sensed operating pressure of the injected fluidic material exceeds a predetermined value, then radially expanding and plastically deforming the tubular member within the preexisting structure.

22. The method of claim 21, wherein sensing the operating pressure of the injected fluidic material comprises sensing the operating pressure of the injected fluidic material using a sensor positioned within the expandable tubular member.
23. The method of claim 21, further comprising:
if the sensed operating pressure of the injected fluidic material exceeds a predetermined value, then permitting the injected fluidic material to pass through a flow passage within the expandable tubular member.
25. The method of claim 23, further comprising:
injecting a hardenable fluidic sealing material through and out of the interior of the expandable tubular member into an annulus between the expandable tubular member and the preexisting structure.
26. The method of claim 25, further comprising:
preventing the injected hardenable fluidic sealing material from passing through the flow passage.
27. The method of claim 21, further comprising:
injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure before radially expanding and plastically deforming the tubular member within the preexisting structure.
28. The method of claim 21, further comprising:
injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure after radially expanding and plastically deforming the tubular member within the preexisting structure.
29. A method of radially expanding and plastically deforming a tubular member within a preexisting structure, comprising:
sensing the operating pressure within the tubular member; and
if the sensed operating pressure within the tubular member exceeds a predetermined value, then radially expanding and plastically deforming the tubular member within the preexisting structure.
30. A method of radially expanding and plastically deforming a tubular member within a preexisting structure, comprising:

- controlling the flow of fluidic materials within the tubular member using one or more movable valve elements;
- sensing an operating pressure of the fluidic materials within the tubular member; and
- if the sensed operating pressure within the tubular member exceeds a predetermined valve, then radially expanding and plastically deforming the tubular member within the preexisting structure using an expansion device.
31. The method of claim 30, further comprising:
- during the radially expansion and plastic deformation of the tubular member,
- displacing the expansion device away from the valve elements.
32. The method of claim 30, further comprising:
- supporting the tubular member within the preexisting structure using a support member; and
- releasably coupling one or more of the valve elements to the support member.
33. The method of claim 30, further comprising:
- coupling the valve elements to an end of the tubular member.
34. A method of radially expanding and plastically deforming a tubular member within a preexisting structure, comprising:
- supporting the tubular member within the preexisting structure using a support member;
- controlling the flow of fluidic materials within the tubular member using one or more movable valve elements that are coupled to an end of the tubular member;
- sensing an operating pressure of the fluidic materials within the tubular member; and
- if the sensed operating pressure within the tubular member exceeds a predetermined valve, then radially expanding and plastically deforming the tubular member within the preexisting structure using an expansion device;
- wherein during the radial expansion and plastic deformation of the tubular member using the expansion device, the expansion device is displaced away from the valve elements; and
- wherein one or more of the valve elements are releasably coupled to the support member.
35. A method of radially expanding and plastically deforming a tubular member within a preexisting structure, comprising:

radially expanding and plastically deforming the tubular member within the preexisting structure; and
injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure;
wherein injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure comprises:
injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure after radially expanding and plastically deforming the tubular member within the preexisting structure.

36. A system for radially expanding and plastically deforming a tubular member within a preexisting structure, comprising:

means for radially expanding and plastically deforming the tubular member within the preexisting structure; and

means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure;

wherein the means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure comprises:

means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure after radially expanding and plastically deforming the tubular member within the preexisting structure.

37. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

a support member;

an expansion device coupled to the support member comprising an external expansion surface;

one or more pressure sensors coupled to the support member;

an expandable tubular member coupled to the expansion surface of the expansion device comprising a first portion and a second portion, wherein the inside diameter of the first portion is less than the inside diameter of the second portion; and

a movable valve coupled to the support member for controlling the flow of fluidic materials through the interior of the expandable tubular member;

wherein the pressure sensors comprise valve elements for controlling the flow of fluidic materials within the interior of the expandable tubular member.

38. A system for radially expanding and plastically deforming a tubular member within a preexisting structure, comprising:
- means for radially expanding and plastically deforming the tubular member within the preexisting structure;
 - means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure; and
 - valve means for controlling the flow of fluidic materials within the interior of the tubular member.
39. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:
- a support member;
 - an expansion device coupled to the support member comprising an external expansion surface;
 - one or more pressure sensors coupled to the support member;
 - an expandable tubular member coupled to the expansion surface of the expansion device comprising a first portion and a second portion, wherein the inside diameter of the first portion is less than the inside diameter of the second portion;
 - a movable valve coupled to the support member for controlling the flow of fluidic materials through the interior of the expandable tubular member; and
 - a tubular member movably coupled to the support member that defines an internal passage having a plug seat.
40. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:
- a support member;
 - an expansion device coupled to the support member comprising an external expansion surface;
 - one or more pressure sensors coupled to the support member;
 - an expandable tubular member coupled to the expansion surface of the expansion device comprising a first portion and a second portion, wherein the inside diameter of the first portion is less than the inside diameter of the second portion; and

a movable valve coupled to the support member for controlling the flow of fluidic materials through the interior of the expandable tubular member; wherein the tubular member is coupled to the second portion of the expandable tubular member.

41. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:

- a support member;
- an expansion device coupled to the support member comprising an external expansion surface;
- one or more pressure sensors coupled to the support member;
- an expandable tubular member coupled to the expansion surface of the expansion device comprising a first portion and a second portion, wherein the inside diameter of the first portion is less than the inside diameter of the second portion; and
- a movable valve coupled to the support member for controlling the flow of fluidic materials through the interior of the expandable tubular member; wherein the movable valve element is releasably coupled to the support member.

42. A method of radially expanding and plastically deforming a tubular member within a preexisting structure, comprising:

- injecting fluidic material into the tubular member;
- sensing the operating pressure of the injected fluidic material; and
- if the sensed operating pressure of the injected fluidic material exceeds a predetermined value, then radially expanding and plastically deforming the tubular member within the preexisting structure;

wherein sensing the operating pressure of the injected fluidic material comprises sensing the operating pressure of the injected fluidic material using a sensor positioned within the expandable tubular member.

43. A system for radially expanding and plastically deforming a tubular member within a preexisting structure, comprising:

- means for radially expanding and plastically deforming the tubular member within the preexisting structure;
- means for injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure; and

means for sensing the operating pressure of fluidic materials within the tubular member that is positioned within the tubular member.

44. A method of radially expanding and plastically deforming a tubular member within a preexisting structure, comprising:
- radially expanding and plastically deforming the tubular member within the preexisting structure;
 - injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure; and
 - sensing the operating pressure of fluidic materials within the tubular member using a sensor positioned within the tubular member.
45. A method of radially expanding and plastically deforming a tubular member within a preexisting structure, comprising:
- injecting fluidic material into the tubular member;
 - sensing the operating pressure of the injected fluidic material;
 - if the sensed operating pressure of the injected fluidic material exceeds a predetermined value, then radially expanding and plastically deforming the tubular member within the preexisting structure; and
 - injecting a hardenable fluidic sealing into an annulus between the tubular member and the preexisting structure after radially expanding and plastically deforming the tubular member within the preexisting structure.
46. A method of radially expanding and plastically deforming a tubular member within a preexisting structure, comprising:
- controlling the flow of fluidic materials within the tubular member using one or more movable valve elements;
 - sensing an operating pressure of the fluidic materials within the tubular member;
 - if the sensed operating pressure within the tubular member exceeds a predetermined valve, then radially expanding and plastically deforming the tubular member within the preexisting structure using an expansion device; and
 - during the radially expansion and plastic deformation of the tubular member, displacing the expansion device away from the valve elements.
47. A system for radially expanding and plastically deforming a tubular member, comprising:

- an expansion device for radially expanding and plastically deforming the tubular member; and
 - a sensor coupled to the expansion device for controlling the operation of the expansion device and positioned within the tubular member for sensing operating conditions within the tubular member.
48. A method of radially expanding and plastically deforming a tubular member, comprising:
- radially expanding and plastically deforming the tubular member using an expansion device; and
 - controlling the operation of the expansion device using a sensor positioned within the tubular member for sensing operating conditions within the tubular member.
49. A system for radially expanding and plastically deforming a tubular member, comprising:
- means for radially expanding and plastically deforming the tubular member using an expansion device; and
 - means for controlling the operation of the expansion device using a sensor positioned within the tubular member for sensing operating conditions within the tubular member.
50. An apparatus for radially expanding and plastically deforming an expandable metallic tubular member, comprising:
- a support member;
 - an expansion device coupled to the support member comprising an external expansion surface;
 - one or more pressure sensors coupled to the support member;
 - an expandable metallic tubular member coupled to the expansion surface of the expansion device comprising a first portion and a second portion, wherein the inside diameter of the first portion is less than the inside diameter of the second portion; and
 - a movable valve coupled to the support member for controlling the flow of fluidic materials through the interior of the expandable metallic tubular member.
51. An apparatus for radially expanding and plastically deforming an expandable tubular member, comprising:
- a support member;

an expansion device coupled to the support member comprising an external expansion surface;
one or more pressure sensors coupled to the support member;
an expandable tubular member coupled to the expansion surface of the expansion device; and
a movable valve coupled to the support member for controlling the flow of fluidic materials through the interior of the expandable tubular member;
wherein the pressure sensors are positioned within the expandable tubular member.

52. A method of radially expanding and plastically deforming a metallic tubular member within a preexisting structure, comprising:

injecting fluidic material into the metallic tubular member;
sensing the operating pressure of the injected fluidic material; and
if the sensed operating pressure of the injected fluidic material exceeds a predetermined value, then radially expanding and plastically deforming the metallic tubular member within the preexisting structure.

53. A method of radially expanding and plastically deforming a metallic tubular member within a preexisting structure, comprising:

sensing the operating pressure within the metallic tubular member; and
if the sensed operating pressure within the metallic tubular member exceeds a predetermined value, then radially expanding and plastically deforming the metallic tubular member within the preexisting structure.

54. A method of radially expanding and plastically deforming a metallic tubular member within a preexisting structure, comprising:

controlling the flow of fluidic materials within the metallic tubular member using one or more movable valve elements;
sensing an operating pressure of the fluidic materials within the metallic tubular member; and
if the sensed operating pressure within the metallic tubular member exceeds a predetermined value, then radially expanding and plastically deforming the tubular member within the preexisting structure using an expansion device.

55. A method of radially expanding and plastically deforming a metallic tubular member within a preexisting structure, comprising:

supporting the metallic tubular member within the preexisting structure using a support member;

controlling the flow of fluidic materials within the metallic tubular member using one or more movable valve elements that are coupled to an end of the metallic tubular member;

sensing an operating pressure of the fluidic materials within the metallic tubular member, and

if the sensed operating pressure within the metallic tubular member exceeds a predetermined value, then radially expanding and plastically deforming the metallic tubular member within the preexisting structure using an expansion device;

wherein during the radial expansion and plastic deformation of the metallic tubular member using the expansion device, the expansion device is displaced away from the valve elements; and

wherein one or more of the valve elements are releasably coupled to the support member.

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